COMBUSTION ENVIRONMENT CONTROL SYSTEM

FIELD OF THE INVENTION

The present invention pertains to the field of combustion and in particular to a system enabling the control of a combustion environment thereby adjusting the affect of ambient temperatures on combustion quality.

BACKGROUND

As is known to a worker skilled in the art, combustion is a rapid chemical reaction combining fuel components with air resulting in reaction by-products together with heat and light. In order for a proper reaction to occur the fuel to air ratio should be within a predetermined level and this level is directly dependent on the type of fuel being combusted. For example, when this ratio is defined in terms of the mass of air to the mass of fuel, the amount of air required for the combustion of natural gas is greater than that required for coal.

Central heating systems employing a hot fluid circulating through a network of pipes have been used for many years for room space heating, snow melting, indirect swimming pool heating, ground heating and other similar purposes. Such systems are now generically referred to as hydronic heating systems.

One of the biggest problems with hydronic heating systems is combustion efficiency. In environments where temperatures change significantly, the fuel to air ratio can deviate significantly from an optimum predetermined ratio. Poor combustion efficiency can result in greater fuel usage and incomplete combustion, wherein incomplete combustion can produce soot. The potential build-up of soot can become a problem for boiler systems, particularly those that are oil fired. Soot that accumulates on the walls of the heat transfer surfaces significantly reduces the efficiency of the boiler since it can impede heat transfer. For this reason the conventionally known oil fired boilers require frequent cleaning in order to maintain peak operating efficiency.

One of the most effective ways to achieve improved combustion efficiency is to preheat the combustion reactants used by the burner. It is well known that preheating fuel improves the efficiency and cleanliness of the burning process. It has been found that by preheating the fuel before it is burned, the viscosity and other properties of the fuel are affected so that the burner utilises less fuel to provide the same amount of heat energy.

Fuel preheaters of the prior art often have an external power source such as electricity to power an electric heater to heat the fuel before it is passed to the burner nozzle. Other prior art systems pass the fuel in pipes through tanks which contain heated water directed from the boiler to increase the temperature of the fuel before it enters the fuel burner for combustion. U.S. Patents Nos. 5,109,807, 4,390,007, 4,719,877, 5,221,043 describe the various fuel preheaters.

It is also known that preheating of combustion air going to the burner is another way to improve efficiency and productivity. Similar to preheating fuel, the preheating of combustion air can result in more heat from a given amount of fuel.

In general, combustion air preheaters for fuel burners and like systems utilise combustion exhaust gas heat to preheat combustion air before being introduced to the burner. U.S. Patents Nos. 4,664,096, 4,751,913, 4,369,029, 4,015,932 and Canadian Patent No. 2,233,053 describe various combustion air preheaters using exhaust gas. While these examples provide a means for preheating combustion air, they do not provide a means for preheating combustion air during cold starts. During cold start operations, hot combustion gases are not yet available and thus preheating of combustion air therewith is not possible.

Further combustion air preheating systems are known, with various improvements, such as that disclosed in U.S. Patent No. 4,369,029. The system disclosed therein describes a ceramic recuperator for the heating of combustion air. The recuperator is provided with means, especially electrically operated, for heating the ceramic body so that initial combustion air can be heated before firing of the burner and further heating of the recuperator by combustion products.

In light of the foregoing, there is a need for a system enabling the control of the combustion environment thereby adjusting the affect of ambient temperatures on the combustion quality in all modes of operation.

This background information is provided for the purpose of making known information believed by the applicant to be of possible relevance to the present invention. No admission is necessarily intended, nor should be construed, that any of the preceding information constitutes prior art against the present invention.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a combustion environment control system. In accordance with an aspect of the present invention, there is provided a system for controlling a combustion environment within a combustion chamber of a hydronic heating unit, said hydronic heating unit including a boiler containing a heat transfer fluid (HTF), a heating element disposed within the combustion chamber associated with the boiler and a fluid distribution network in fluidic contact with the boiler thereby enabling movement of the HTF, said system comprising: a first heating unit for adjusting fuel temperature, wherein fuel being transferred from a fuel source to the heating element has a predetermined temperature upon arrival at the heating element, said first heating unit including a first chamber and second chamber in thermal conductive contact, whereby regulating the HTF through the second chamber enables regulation of the fuel temperature of the fuel passing through the first chamber; a second heating unit for adjusting combustion air temperature, wherein combustion air transferred to the heating element has a predetermined temperature upon arrival at the heating element, said second heating unit having a first portion and a second portion in thermal conductive contact, whereby regulating the HTF through the second portion enables regulation of the combustion air temperature of the combustion air passing through the first portion; and a third heating unit interconnected with the boiler for heating the HTF to an operational temperature, such that the operational temperature of the HTF is sufficient to adjust fuel temperature and combustion air temperature to predetermined levels prior to ignition of the heating element.

In another object of the present invention there is provide A method for controlling a combustion environment within a combustion chamber of a hydronic heating unit, said hydronic heating unit including a boiler containing a HTF, a heating element disposed within the combustion chamber associated with the boiler, a fluid distribution network in fluidic contact with the boiler thereby enabling movement of the HTF, a fuel preheater disposed within the fluid distribution network, a combustion air preheater disposed within the fluid heating network, and a cold start preheater associated with the boiler, said method comprising: detecting the temperature of the HTF within the boiler; adjusting the temperature of the HTF within the boiler to a predetermined operating temperature; detecting the temperature of fuel and combustion air entering the combustion chamber; adjusting the temperature of fuel and combustion air entering the combustion chamber to a predetermined operating temperature; and repeating the steps of detecting the temperature of fuel and combustion air entering the combustion chamber and adjusting the temperature of fuel and combustion air entering the combustion chamber to maintain the predetermined operating temperature.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic of the combustion environment control system according to one embodiment of the present invention.

Figure 2 is a schematic of a first heating unit according to one embodiment of the present invention.

Figure 3 is a cross section of the first heating unit of Figre 2 taken at Section A-A.

Figure 4 is a schematic of a first heating unit according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Definitions

The term "heat transfer fluid" ("HTF") means any fluid used to carry heat to operate various fans, coils, or other thermal radiant devices and includes water, any mixture of water & anti-freeze, air, or any other fluid that is safe for use as a HTF for hydronic heating systems.

The term "operating temperature" refers to the peak temperature of the HTF in the boiler when the system is running normally and not on a cold start.

The term "cold start" refers to starting conditions where the system has been shut down and where the HTF in the boiler is below operating temperature.

The term "optimum fuel temperature" refers to the temperature of the fuel entering the combustion chamber that would provide the most efficient combustion when it is burned therein.

The term "optimum combustion air temperature" refers to the temperature of the air entering the combustion chamber that would provide the most efficient combustion.

The term "fuel" means any light oils such as #1 or #2 heating oil, summer, winter or blended diesel fuel, kerosene and jet fuels of equivalent weight, and like fuels.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.

The invention provides a system enabling the control of a combustion environment thereby adjusting the affect of ambient temperatures on the combustion quality on all modes of operation. The system can be described as a system for controlling a combustion environment within a combustion chamber of a hydronic heating system comprising a boiler containing a HTF, a burner within a combustion chamber, and a fluidic distribution network in fluidic contact with the boiler thereby enabling movement of HTF. The temperature control system comprises a first

heating unit for adjusting the temperature of the fuel fed to the burner, a second heating unit for adjusting combustion air temperature and a third heating unit associated with the boiler to heat the HTF in the boiler to operating temperature in a cold start scenario, wherein the HTF is below the operating temperature.

By heating both fuel and combustion air in one system, substantial fuel savings may be effected and can reduce maintenance costs. Further benefits may be achieved, by having a means to preheat both fuel and combustion air during cold start situations.

Figure 1 illustrates a schematic view of the combustion environment control system **200** according to one embodiment of the present invention. The combustion environment control system **200** includes a first heating unit **50**, a second heating unit **60**, a third heating unit **70**, and a boiler **10** containing a HTF.

The HTF is heated in the boiler's **10** supply manifold using a burner **20** which is housed within a combustion chamber (not shown). The boiler **10** includes a boiler supply manifold and a return manifold. The boiler **10** supplies the HTF supply line **130** with hot HTF from its main supply manifold. The hot HTF exits the boiler **10** at a boiler outlet **150** and a system pump **40** pressurises the system and circulates the hot HTF through the HTF supply line **130**. After circulating throughout the HTF supply line **130**, the cooled HTF returns via the boiler return line **140** to the boiler's **10** return manifold through the boiler inlet **160** where it is reheated to operating temperature.

First Heating Unit

The first heating unit **50** is used to adjust the temperature of the fuel that is supplied to the burner **20**. The first heating unit **50** is thermally coupled to the fuel preheat line **132**. The fuel preheat line **132** is branched off of the HTF supply line **130** thereby supplying hot HTF to the first heating unit **50**. A flow control valve **90** is incorporated in the fuel preheat line **132** between the first heating unit **50** and the HTF supply line **130** enabling control of the flow of HTF to the first heating unit **50** based on feedback from a thermostatic fuel temperature sensor **100**. Fuel is

supplied to the first heating unit **50** from the fuel tank **30** using a fuel pump (not shown) which is integrally associated with the burner. A fuel filter **80** is incorporated in the fuel supply line **85** on the inlet side of the first heating unit **50**. The fuel temperature sensor **100** is immersed in the fuel reservoir within the first heating unit **50**. The fuel temperature sensor **100** measures the temperature of the heated fuel and is associated with the flow control valve **90**. Based on feedback from the fuel temperature sensor **100**, the flow control valve **90** regulates the flow of the hot HTF such that the temperature of the heated fuel exiting the first heating unit **50** and entering the burner **20** is within a range of about ± 0.5°C or ± 3 °C of the optimum fuel temperature, or any range there between.

In another embodiment of the invention, the fuel pump is incorporated within the fuel supply line **85** outside of the burner assembly.

Disposed within the first heating unit **50** are fluid-to-fuel heat transfer means. Said fluid-to-fuel heat transfer means comprises of a first chamber and a second chamber in thermal conductive contact, whereby regulating the hot HTF through the second chamber enables regulation of the fuel temperature of the fuel passing through the first chamber.

In one embodiment the fluid-to-fuel heat transfer means is a fuel heater assembly comprising an interior, cylindrical, fuel reservoir about 4" in diameter and 24" long (approximately 1.3 U.S. gallons) with an inlet at one longitudinal end to receive filtered fuel from the fuel tank **30** and an outlet at the opposite longitudinal end to supply heated fuel to the burner **20**. An exterior HTF reservoir comprising a jacket about ½" thick encompassing the fuel reservoir with an inlet at one longitudinal end to receive hot HTF from the fuel preheat line **132** and an outlet at the opposite end connected to the boiler return line **140**. The fuel temperature sensor **100** is immersed in the fuel reservoir at the outlet end of the fuel reservoir. With the fuel heater assembly mounted vertically, fuel enters through the fuel reservoir inlet from the bottom of the fuel heater assembly and exits from the fuel reservoir outlet at the top. HTF enters through the HTF jacket inlet at the top of the fuel heater assembly and exits through HTF jacket outlet at the bottom, creating a counter-flow heat transfer situation. This embodiment of the the first heating unit is illustrated in Figures 2 and 3.

In another embodiment and with reference to Figure 4, the fuel heater assembly comprises of a helical pipe as a fuel reservoir that is interconnected to the fuel supply line **85** such that the first end receives fuel from the fuel tank **30** and the second end supplies heated fuel to the burner **20**. The helical pipe is enclosed within a cylindrical reservoir of HTF interconnected to the fuel preheat line **132** with an inlet at one end to receive hot HTF and outlet at the other to expel cooled HTF to the boiler return line **140.** A fuel temperature sensor **100** is immersed in the fuel reservoir at the second end of the helical pipe. With the fuel heater assembly mounted vertically, fuel enters the inlet of the helical pipe at bottom of the fuel heater assembly and exits through the second end at the top. HTF enters through the cylindrical reservoir of HTF inlet at the top of the fuel heater assembly and exits through the outlet at the bottom, creating a counter-flow heat transfer situation.

In another embodiment, the fuel heater assembly comprises of a helical pipe interconnected to the fuel preheat line **132** such that the first end receives hot HTF and the second end returns cooled HTF to the boiler **10**. The helical pipe is enclosed within a cylindrical reservoir of fuel interconnected to the fuel supply line **85** with an inlet at a first end to receive fuel from the fuel tank **30** and a second end to supply heated fuel to the burner **20**. The temperature sensor **100** is immersed in the cylindrical reservoir of fuel at the second end of the fuel reservoir. With the fuel heater assembly mounted vertically, fuel enters the first end of the cylindrical reservoir at bottom of the fuel heater assembly and exits through the second end at the top. HTF enters the helical pipe at the top of the fuel heater assembly and exits through the outlet at the bottom, creating a counter-flow heat transfer situation.

In another embodiment, the fuel heater assembly comprises a fuel inlet that is proximate to the HTF inlet and a fuel outlet proximate to the HTF outlet thereby creating a concurrent flow heat transfer situation.

In another embodiment, the fuel temperature sensor **100** is integrally associated with the burner's fuel intake.

In one embodiment of the invention, the flow control valve **90** is electronically controlled by an internal or integrated control system in the form of a microprocessor for example, which provides a means for regulating the flow of the HTF to the first heating unit based on information received from the fuel temperature sensor **100**. This internal control system, can manipulate the flow control valve between a plurality of flow regulation levels, thereby enabling the minor adjustment in the flow rate of HTF to the first heating unit. Optionally, the flow control valve can be operated an external control system and in one embodiment a single control system is used to control the valves associated with both the first and second heating units.

Second Heating Unit

The second heating unit **60** is used to adjust the temperature of air that is supplied to the burner **20**. The second heating unit **60** is thermally coupled to the combustion air preheat line **134**. The combustion air preheat line **134** is branched off of the HTF supply line **130** and supplies hot HTF to the second heating unit **60**. A flow control valve **110** is incorporated in the combustion air preheat line **134** to control the flow of HTF to the second heating unit **60**. Ambient air is supplied to the second heating unit **60** by an air movement device (not shown) juxtaposed to the second heating unit **60**. A thermostatic air temperature sensor **101** is located within the second heating unit **60** downstream from the ambient air source. Based on feedback from the air temperature sensor **101**, the flow control valve **110** regulates the flow of the hot HTF such that the temperature of the heated air exiting the second heating unit **60** and entering the combustion chamber is within a range of about ± 0.5°C or ± 3 °C of the optimum combustion air temperature, or any range there between.

Disposed within the second heating unit **60** is an air-to-fluid heat transfer means. Said air-to-fluid heat transfer means generally comprises of a first portion and a second portion in thermal conductive contact, whereby regulating the HTF through the second portion enables the regulation of the temperature of the combustion air passing through the first portion.

In one embodiment the air-to-fluid heat transfer means is a combustion air heater assembly comprising a fluid-to-air heat exchange coil or a radiator-like system placed within the air flow in

a duct system that, for example, routes ambient air to the burner's combustion air inlet. Hot HTF is supplied from the combustion air preheat line **134** to the fluid-to-air heat exchange coil regulating the temperature of the air flow and then returned to the boiler return line **140**. An air movement device (not shown), which is integrally associated with the burner **20**, draws ambient air which is then forced through the duct system and passed over the air-to-fluid heat exchange coil thereby heating the air. The air temperature sensor **101** is located at one end of the duct system opposite the ambient air source.

In another embodiment the air movement device (not shown) is located within the duct system external to the burner assembly.

In another embodiment the combustion air heater assembly comprises of fluid-to-air heat exchange coil disposed within the combustion chamber with the burner **20**, and an ambient air inlet associated with the fluid-to-air heat exchange coil. As air is burned off within the combustion chamber, ambient air is drawn into the chamber through the air inlet and passed through the fluid-to-air heat exchange coil. An air temperature sensor **101** is located downstream of the air flow from the fluid-air-heat exchange coil. Based on feedback from the air temperature sensor **101**, the flow control valve **110** regulates the flow of the hot HTF such that the temperature of the heated air entering the combustion chamber is within a range of about ± 0.5°C or ± 3 °C of the optimum combustion air temperature, or any range there between.

In one embodiment of the invention, the flow control valve **110** is electronically controlled by an internal or integrated control system internal thereto in the form of a microprocessor for example, which provides a means for regulating the flow of the HTF to the second heating unit based on information received from the air temperature sensor **101**. This internal control system, can manipulate the flow control valve between a plurality of flow regulation levels, thereby enabling the minor adjustment in the flow rate of HTF to the second heating unit. Optionally, the flow control valve can be operated an external control system.

Third Heating Unit

The third heating unit **70** is used to adjust the temperature of the HTF on cold starts of the hydronic heating system. The heating means of the third heating unit **70** is an electric heater in the form of a resistor, for example, or any other electrical heating device as would be known to a worker skilled in the art. The third heating unit is vertically disposed and is coupled to the boiler **10**. A thermostatic HTF temperature sensor (not shown) is associated with the HTF reservoir of the boiler **10** and is used to regulate the operation of the electric heating means such that power to the third heating unit **70** is interrupted when the HTF within the boiler reaches operating temperature. Power to the electric heating means is electrically interlocked with the system pump **40** such that the system pump **40** can not be energised if the electric heating means is activated. An HTF fluid level sensor (not shown) is located within the boiler **10** and is used to interrupt power to the third heating unit **70** when the system is low on HTF.

Disposed within the third heating unit **70** is electric heating means in thermal-conductive contact with an HTF reservoir. An example of electric heating means is an electric heater in the form of a resistor.

In one embodiment, the third heating unit comprises a vertically disposed, thermal conductive container with an interior HTF reservoir with a top and bottom end. The bottom end of the third heating unit **70** is coupled to a port near the bottom of the boiler's water jacket and the top end of the third heating unit **70** is couple to a port near the top of the boiler's water jacket. A resistor-based electric heating element is affixed to the exterior of the HTF reservoir. HTF enters the bottom end of the third heating unit **70** and is heated through the interior reservoir wall by the electric heater as it circulates therein. Through convective circulation, the hot HTF exits the third heating unit **70** at the top end and is fed back into the boiler's supply reservoir.

In another embodiment of the invention, the third heating unit **70** comprises of a resistor-based heating element affixed to the exterior housing of the boiler **10**. The HTF in the boiler is heated to operating temperature directly through the boiler's housing.

In another embodiment of the invention, the third heating unit **70** comprises of one or more resistor-based heating elements inserted into the boiler's HTF reservoir in direct contact with the HTF.

Sequence of Events during Normal Operation

Hot HTF exiting the boiler into the HTF supply line **130** is branched into the fuel preheat line **132** and combustion air preheat line **134** whereupon it enters the first heating unit **50** and second heating unit **60**, respectively.

The hot HTF in the first heating unit **50** heats the fuel contained therein. When the temperature of the fuel exiting the first heating unit **50** and into the combustion chamber deviates within a range of ± 0.5°C or ± 3 °C of the optimum fuel temperature or any range there between, the fuel temperature sensor associated with the first heating unit **50** communicates with the flow control valve **90** incorporated in the fuel preheat line **132** to adjust the flow of hot HTF to the first heating unit **50** sufficiently to restore the temperature of the fuel exiting the first heating unit **50** to optimum fuel temperature. The heated fuel is then supplied to the burner **20** located within the combustion chamber.

Similar to the first heating unit **50**, hot HTF in the second heating unit **60** heats the ambient air that is supplied by the air movement device (not shown). When the temperature of the air exiting the second heating unit **60** and entering the combustion chamber deviates within a range of ± 0.5°C or ± 3 °C of the optimum combustion air temperature or any range there between, the air temperature sensor **101** associated with the second heating unit **60** communicates with the flow control valve **110** incorporated in the combustion air preheat line **134** to adjust the flow of hot HTF to the second heating unit **60** sufficiently to restore the temperature of the air exiting the second heating unit **60** to optimum combustion air temperature. The heated air is then supplied to the burner within the combustion chamber.

The hot HTF circulating through the first heating unit **50** and the second heating unit **60** is looped back to the boiler **10** where it is reheated to operating temperature.

Sequence of Events on Cold Starts

On cold starts, the electric heating means of the third preheat unit **70** is engaged and the system pump **40** is disengaged.

In one embodiment of the invention, cold HTF is supplied into the third heating unit **70** from the boiler **10** where it is heated therein and is returned to the boiler **10**. When the temperature of the HTF in the boiler **10** reaches operating temperature, the electric heating means is disengaged and the system pump **40** is activated. The system then operates in normal operation.

In another embodiment of the invention, the HTF in the boiler **10** is heated directly through the boiler housing by electric means. When the temperature of the HTF in the boiler **10** reaches operating temperature, the electric heating means is disengaged and the system pump **40** is activated. The system then operates in Normal Operation.

Proposed Uses

The invention is designed to be portable and customisable depending upon its intended application. The size and shape of each heating unit will vary depending on the environment to which it is used and its intended use. For example, applications in extreme cold conditions may require larger heating units with helical pipes to increase the surface area for the pre-heating of fuel and air; temporary applications in moderate climates may require smaller heating units to maximize portability such as in construction sites.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.